

Taxonomic Revival of *Pedicularis japonica* from *P. chamissonis* (Orobanchaceae)

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In our previous studies, two independent entities within *Pedicularis chamissonis* Steven (the Northern type and the Central Honshu type) were revealed from an analysis of genetic, morphological and ecological data. Based on relevant taxonomic literature and specimens of *P. chamissonis*, we propose the revival of the name *P. japonica* Miq. for the plants of the Central Honshu type and *P. chamissonis* sensu stricto for the Northern type.

Key words: alpine plant, central Honshu, clade, cpDNA, endemic species, Japan, Orobanchaceae, *Pedicularis chamissonis*, *Pedicularis japonica*

Pedicularis chamissonis Steven (Orobanchaceae) is a perennial herb distributed along the North Pacific coast from the Japanese archipelago to southwest Alaska (Hultén 1930, Yamazaki 1993). It was classified in ser. *Myriophyllae* Maxim., sect. *Orthosiphonia* H. L. Li (Yamazaki 1993). Species of series *Myriophyllae* are characterized by their erect or ascending stems, whorled or pinnatisect leaves, racemose or spicate inflorescences, erect corolla tube, and the apex of the corolla extending into a beak (Li 1948). *P. chamissonis* is highly diverse in its external morphology, so that several intraspecific taxa have been proposed (Hara 1948, Kitamura *et al.* 1958, Ohwi 1978, Shimizu 1982, Yamazaki 1987, 1993). Yamazaki (1993) recognized three varieties within the Japanese archipelago: var. *japonica* (Miq.) Maxim., var. *rebunensis* T. Yamaz. and var. *longirostrata* T. Yamaz..

According to the phylogeographic studies of Fujii *et al.* (1997) of variation in *Pedicularis chamissonis* using non-coding regions of cpDNA (approx. 1800 bp), two major cpDNA clades were

revealed, the Northern clade and the Central Honshu clade (Fig. 1). The geographical distribution of the two clades is highly structured: The Northern clade includes haplotypes of populations ranging from northern Honshu, Japan, to Unalaska Island in the Aleutians. The Central Honshu clade includes populations from central Honshu, Japan. The distribution of the two clades overlaps on Mt. Gassan and Iide Mtns. in the Tohoku district of Japan.

On Mt. Gassan, Yamagata Prefecture, two cpDNA haplotypes belonging to different, sympatrically distributed clades of *Pedicularis chamissonis* were recognized (Fig. 1). Haplotypes D and J represented the Northern and Central Honshu clades, respectively. Further study of the two haplotypes on Mt. Gassan (Fujii *et al.* 2001), based on the SSCP analysis of chloroplast and nuclear DNA, suggested that no gene flow existed between individuals of the two haplotypes. Furthermore, the two haplotypes differ from each other in corolla and leaf characteristics and the number of floral whorls per inflorescence axis. That study

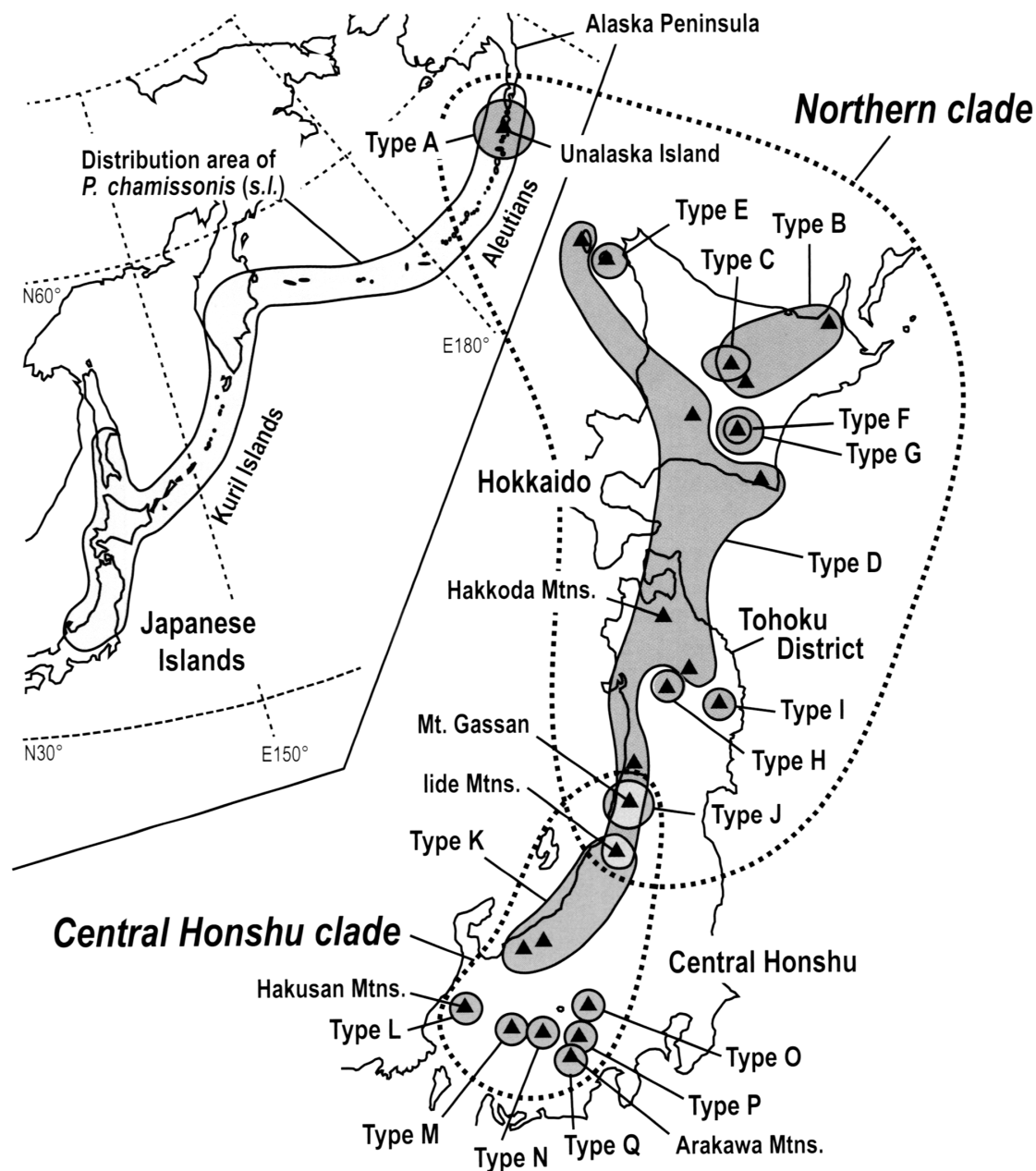


FIG. 1. CpDNA haplotypes of *Pedicularis chamissonis* s.l. (Fujii *et al.* 1997). Two major clades inferred from phylogenetic analysis among haplotypes are also illustrated (the Northern clade and Central Honshu clade). Geographical distribution of the two clades is highly structured.

also clarified that individuals of the two haplotypes grow in different habitats on Mt. Gassan. Plants of haplotype D (Northern clade) usually occur in areas with heavy snowfall or snow flush in winter. In contrast, individuals of haplotype J (Central Honshu clade) usually occur in relatively dryer areas. These observations suggest that the two clades within *P. chamissonis* should be treated as independent biological entities, Northern

type and Central Honshu type. Based on literature search and specimens of *P. chamissonis*, we propose the revival of *P. japonica* Miq. for the Central Honshu type and *P. chamissonis* for the Northern type.

Materials and Methods

More than 450 specimens identified as *Pedic-*

ularis chamissonis were studied from seven herbaria: KANA, KYO, MAK, SAPS, SHIN, TI and TNS. In each herbarium, we focused on the morphological differences clarified by Fujii *et al.* (2001); the proximal part of the corolla tube, the number of floral whorls per inflorescence axis, and the degree of dissection of the leaf pinnae (width between rachis and sinus of pinna of the largest leaf), and then determined whether the specimens were Northern type or Central Honshu type. We determined the number of floral whorls by counting them on fully grown inflorescences and by comparing the mean values of the Northern and Central Honshu types. Locality, date of collection, collector name and collector number from each specimen was recorded. Digital images of the type specimens of *P. chamissonis*, *P. fauriei* Bonati (for a detailed description, see below), and *P. japonica* were examined with the cooperation of the curators of the Finnish Museum of Natural History (H), Conservatoire et Jardin botaniques de la Ville de Genève (G) and Nationaal Herbarium Nederland (L), respectively.

Results and Discussion

Investigation of type specimens and taxonomic treatment

Pedicularis chamissonis Steven was described based on a specimen collected on Unalaska Island, Aleutian Islands, USA (Steven 1823; Fig. 2). *P. japonica* Miq. was described by Miquel (1866) from Hakusan Mtns., Ishikawa Prefecture, central Honshu (Fig. 3). Subsequently, Maximowicz (1877) treated *P. japonica* as a variety of *P. chamissonis*. Later, *P. fauriei* Bonati was described from a specimen from Hakkoda Mtns., northern Honshu, Japan (Bonati 1903). Most botanists have treated *P. fauriei* as a synonym of *P. chamissonis* var. *japonica*.

The treatment by Maximowicz (1877) was accepted by Hultén (1930), Hara (1948), Kitamura *et al.* (1958), Ohwi (1978), Shimizu (1982), Ivaniina (1991), Yamazaki (1993), but Nakai (1909), Matsumura (1912) and Makino and Nemoto (1931) treated them as distinct. Nakai (1909) rec-

ognized the populations ranging from Honshu to the Kuril Islands as *Pedicularis japonica* and those from more northern regions as *P. chamissonis*. That treatment was not accepted by recent taxonomists and over the past half century *P. chamissonis sensu lato (s.l.)* has generally been accepted as including *P. japonica*.

Our previous studies (Fujii *et al.* 1997, 2001) suggested that the Northern type and the Central Honshu type of *Pedicularis chamissonis s.l.* should be treated as different species. The Northern type is widely distributed from Iide Mtns. in central Honshu, Japan, to Unalaska Island in the Aleutians, whereas the Central Honshu type is restricted to Honshu from Mt. Arakawa to Mt. Gas-san (Fig. 1). The distribution of the Northern type includes the population from Unalaska Island, the type locality of *P. chamissonis* (Fig. 2; Steven 1823), and also the population from Hakkoda Mtns., which is the type locality of *P. fauriei* (Bonati 1903). In contrast, the distribution area of the Central Honshu type included the population of Hakusan Mtns., central Honshu, Japan, which is a type locality of *P. japonica* (Fig. 3; Miquel 1866).

The morphological differences between the type specimens of *Pedicularis chamissonis* and *P. japonica* are in concordance with the discriminating morphological characters between the Northern and Central Honshu types clarified by Fujii *et al.* (2001). As shown in Fig. 2, the type specimen of *P. chamissonis* has: 1) the proximal part of the corolla tube evidently curved, 2) many floral whorls (nodes) on the inflorescence axis (6–8), and 3) leaf pinnae deeply dissected. The type specimen of *P. japonica* (Fig. 3) has: 1) the proximal part of the corolla tube straight or slightly curved, 2) the number of floral whorls (nodes) per inflorescence axis relatively few (3 or 4), and 3) leaf pinnae shallowly dissected. Thus, according to Art. 11-4 (the priority rule) of the International Code of Botanical Nomenclature (McNeill *et al.* 2006), we conclude that it is reasonable to adopt the scientific names *P. chamissonis* for the Northern type (Steven 1823) and *P. japonica* for the Central Honshu type (Miquel 1866). In the following description, the term “*P. chamissonis*” in-



FIG. 2. Type specimen of *Pedicularis chamissonis* Steven collected by Ludolf Adelbert von Chamisso on Unalaska Island in 1820. A: Whole specimen. B: Closeup of inflorescence. Unit of scale: 1 cm. Photograph obtained with cooperation of curators at University of Helsinki (H).

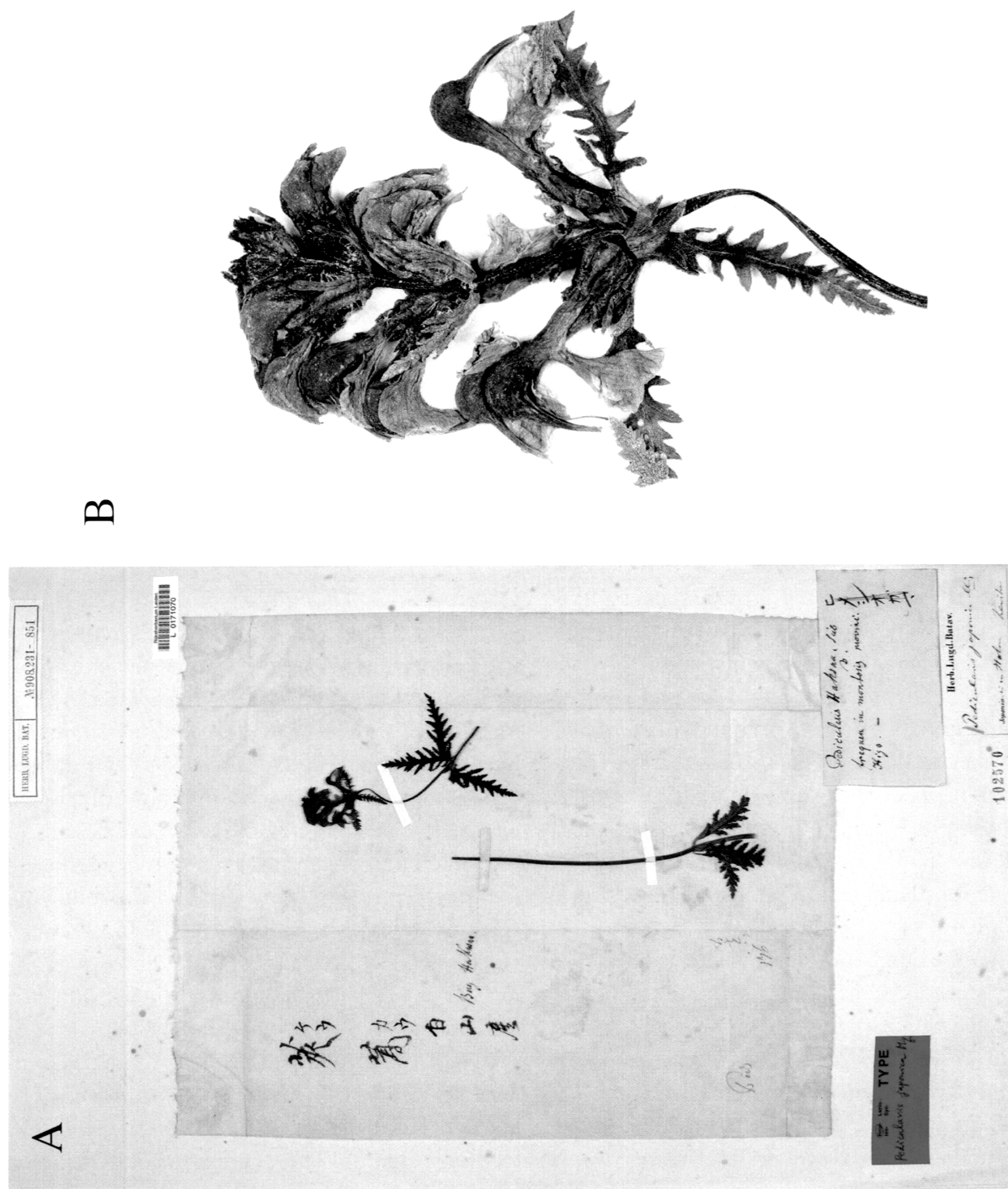


FIG. 3. Type specimen of *Pedicularis japonica* Miq. collected by Keisuke Ito on Hakusan Mtns. (date of collection uncertain). A: Whole specimen. B: Closeup of inflorescence. Photograph obtained with cooperation of curators at Nationaal Herbarium Nederland (L).

dicates *P. chamissonis sensu strict (s.s.)*.

Diagnostic characters separating P. chamissonis and P. japonica

To validate the morphological characteristics described by Fujii *et al.* (2001), we examined herbarium specimens of *Pedicularis chamissonis s.l.* The most effective character for distinguishing *P. chamissonis* and *P. japonica* was the proximal part of the corolla tube. In most specimens of *P. chamissonis*, the proximal part of the corolla tube is clearly curved (Fig. 4A–E), whereas in *P. japonica* it was straight or slightly curved (Fig. 4F–J). The length of the beak of the corolla has frequently been used as diagnostic character for distinguishing intraspecific taxa of *P. chamissonis s.l.* (Shimizu 1982, Yamazaki 1993). The specimens of *P. chamissonis*, however, showed considerable variation in the length of the beak of the corolla; relatively short in specimens from Unalaska Island (Fig. 4A), Aleutians, and relatively long in specimens from Hokkaido and central Honshu (Fig. 4C–E). Most specimens of *P. japonica* have a corolla with a long, slender beak (Fig. 4F–J), as in specimens from Hokkaido and central Honshu of *P. chamissonis*. We thus contend that the length of the beak of the corolla is not appropriate for distinguishing *P. chamissonis* from *P. japonica*.

As for the number of floral whorls (nodes) per inflorescence axis, they ranged from 3 to 20 [averaging 7.8 ± 3.8 (S.D.)] among the 129 specimens of *Pedicularis chamissonis*, whereas in *P. japonica* they ranged from 2 to 9 [average 4.1 ± 1.4 (S.D.)] among the 91 specimens. Although the mean number of floral whorls in *P. chamissonis* was significantly greater than in *P. japonica* (t-test, $P < 0.001$), *P. chamissonis* showed high variation, which overlapped the variation of *P. japonica*. We therefore conclude that it is difficult to distinguish the two species only by the number of floral whorls per inflorescence axis. Since the characteristic shows a general trend, however, we can use the number of floral whorls per inflorescence axis in combination with other features as one of the diagnostic characteristics.

Pedicularis chamissonis s.l. has lanceolate,

lanceolate-oblong, oblong, oblong-ovate or ovate leaf blades, and the leaves are pinnately dissected with 7–12 pairs of segments (Figs. 2, 3, 5). The leaves of *P. chamissonis* are usually larger than those of *P. japonica*. The blades are oblong-ovate, and the pinnae are relatively deeply dissected (Fig. 5A–E). In contrast, the blades of *P. japonica* are relatively small, the blades are lanceolate-oblong, and the degree of dissection is relatively shallow (Fig. 5F–J). In other words, the ratio of width between the rachis and the sinus of the pinna to leaf width in *P. japonica* is relatively greater than in *P. chamissonis*. These characteristics of the leaves are continuous, however. To accurately distinguish the two species it is necessary use not only leaf characteristics, but also those of the corolla and inflorescence.

Distribution and habitat

We found that *Pedicularis chamissonis* is distributed widely in coastal areas of the North Pacific from the Japan to the Aleutian Islands (Fig. 6). Fujii *et al.* (1997) showed that the southernmost populations of *P. chamissonis* are at Iide Mtns. (Fig. 1). The distribution, however, based on specimens examined in this study, extends to the mountains of central Honshu. We confirmed the presence of *P. chamissonis* on the following six mountains: Mt. Shibutsu [July 16, 1929, H. Hara s.n. (TI)], Mt. Tanigawa [July 13, 1953, K. Kanai s.n. (TI)], Mt. Togakushi [August 14, 1903, S. Shimazu s.n. (TI)], Yatsugadake Mtns. [June 29, 1949, M. Kitagawa s.n. (TI)], Mt. Kisokomagadake [August 6, 1903, S. Shimazu s.n. (TI)] and Mt. Kita [August 10, 1963, S. Okamoto s.n. (KYO)] (Fig. 6). The southernmost population was on Mt. Kita, Nagano Prefecture, central Honshu. In this survey, the northernmost specimens we examined were from Unalaska Island, Aleutian Islands, but Hultén (1968) reported it from the western edge of the Alaska Peninsula.

Pedicularis japonica is distributed from central Honshu to the southern Tohoku District and is thus endemic to Japan (Fig. 6). The northernmost population is on Mt. Gassan in the southern Tohoku District, the westernmost population is on Hakusan Mtns. in central Honshu, and the

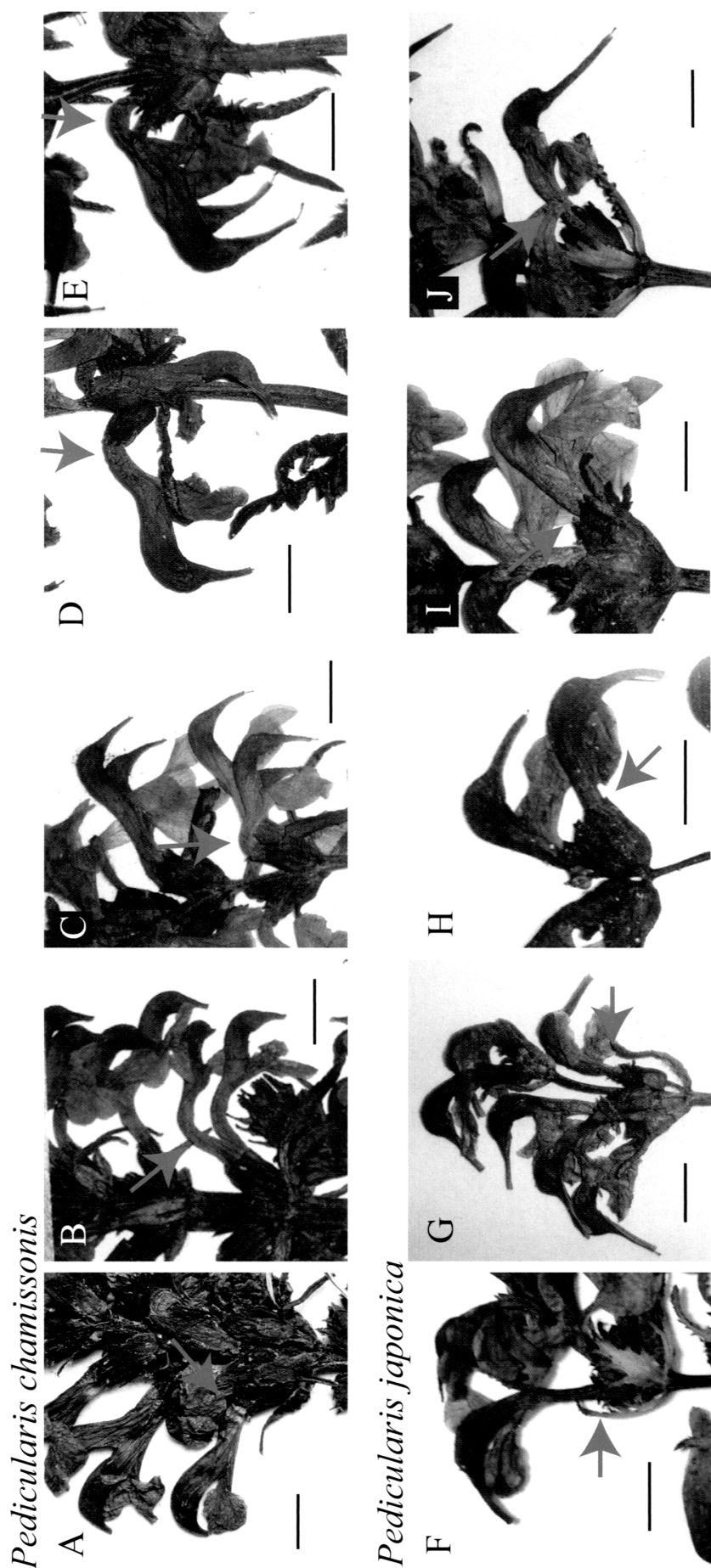


FIG. 4. Comparison of corollas of *Pedicularis chamissonis* and *P. japonica*. Proximal part of corolla tube evidently curved in *P. chamissonis*, (A–E). Proximal part of corolla tube straight or slightly curved in *P. japonica* (F–J, green arrows). Scale bars = 5 mm. A: Unalaska Island, Aleutian Islands [Jul. 25, 1931, Y. Kobayashi s.n. (TNS)], B: Urup Island, Kuril Islands [Jun. –Jul. 1944, K. Watanabe s.n. (TI)], C: Taisetsu Mtns., Hokkaido [M. Hiroe 6677 (TI)], D: Mt. Tottabetsu, Hokkaido [N. Fujii 468 (KANA)], E: Mt. Tanigawa, Honshu [Jul. 13, 1953, K. Kanai s.n. (TI)], F: Mt. Gassan, Honshu [H. Sakai et al. 84015 (KYO)], G: Iide Mtns., Honshu [Jul. 31 1909, S. Tamaki s.n. (TI)], H: Mt. Tsubakuro – Mt. Jonen, Honshu [L. Hurusawa 6697 (TI)], I: Mt. Kisokomagadake, Honshu [Aug. 2 1954, A. Kabe s.n. (TI)], J: Mt. Shiomi, Honshu [Jul. 25, 1947, K. Teramoto s.n. (TI)].

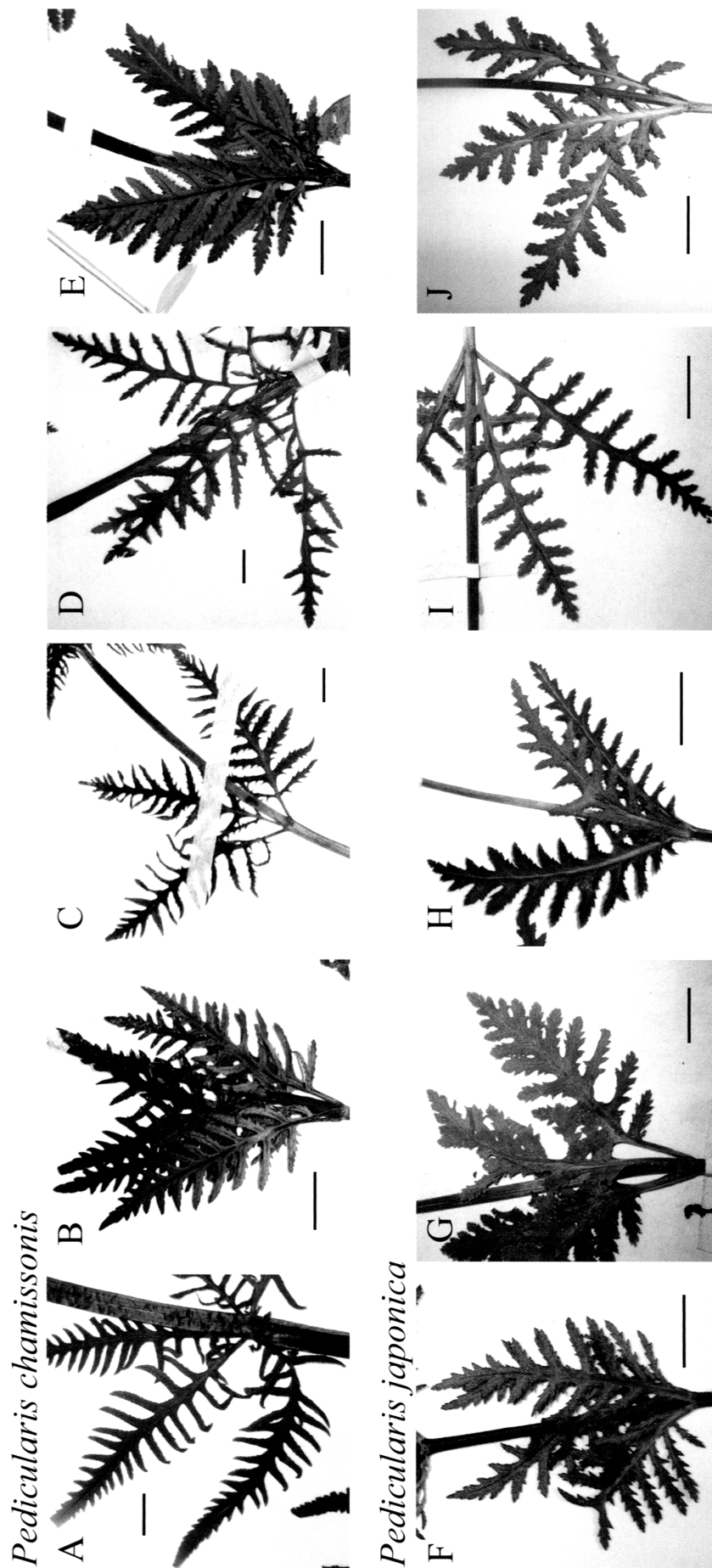


FIG. 5. Comparison of leaf characteristics of *Pedicularis chamissonis* and *P. japonica*. Sinuses of leaf pinnae of *P. chamissonis* relatively deep (A–E) compared to those of *P. japonica* (F–J). Scale bars = 1 cm. A: Urup Island, Kuril Islands [Jun.–Jul. 1944, K. Watanabe s.n. (T1)], B: Mt. Yubari, Hokkaido [Jul. 22, 1979, T. Shimizu s.n. (SHIN)], C: Hakkoda Mtns., Tohoku [N. Fujii 556 (KANA)], D: Yatsugadake Mtns., Honshu [Jun. 29, 1949, M. Kitagawa s.n. (T1)], E: Mt. Kita, Honshu [Aug. 10, 1963, S. Okamoto s.n. (KYO)], F: Mt. Gassan, Tohoku [H. Sakai et al. 84015 (KYO)], G: Iide Mtns., Tohoku [Aug. 8, 1904, G. Nakahara s.n. (T1)], H: Mt. Ontake, Honshu [Aug. 4, 1953, M. Mizushima s.n. (T1)], I: Yatsugadake Mtns., Honshu [Jul. 26, 1908, K. Tandaka s.n. (T1)], J: Mt. Usagi, Akaishi Mtns., Honshu [S. Hojo 14520 (T1)].

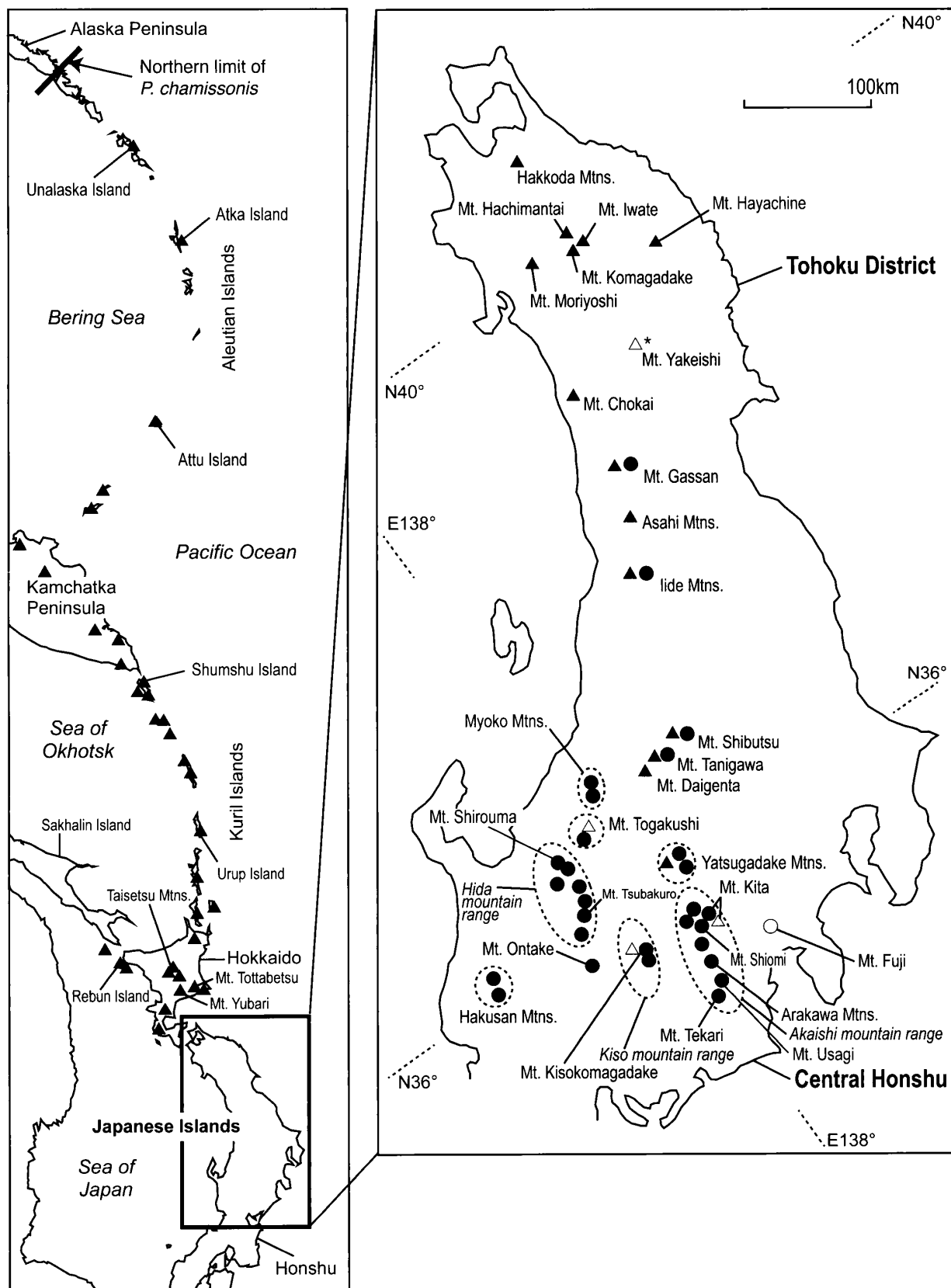


FIG. 6. Geographic distribution of *Pedicularis chamissonis* (▲) and *P. japonica* (●) based on herbarium specimens (KANA, KYO, MAK, SAPS, SHIN, TI, TNS). Single specimens shown by open triangles (△) and open circles (○). *From field observations.

southernmost population is on Mt. Tekari in the Akaishi mountain range of central Honshu. Though most of the specimens from central Honshu were identified as *P. japonica*, a few specimens of *P. chamissonis* have been collected in central Honshu.

Fujii *et al.* (2001) found that *Pedicularis chamissonis* and *P. japonica* grow in different habitats on Mt. Gassan. The former usually occur in areas of heavy snowfall or snow flush in winter, while the latter occur mostly in relatively drier areas. We observed a similar phenomenon in populations on Iide Mtns. Plants of the Central Honshu type were at the ridgeline of the mountains, while those of the Northern type were in the snowy valleys (Ishikorobi-sawa) [N. Fujii F01774 (MAK)]. *P. chamissonis* and *P. japonica* therefore grow in different habitats even though they occur on the same mountain.

Remarks on intraspecific taxa

As mentioned above, several intraspecific taxa of *Pedicularis chamissonis* s.l., including *P. japonica*, have been described. Shimizu (1982) recognized three varieties and one form within *P. chamissonis*; var. *chamissonis*, var. *hokkaidensis*, var. *hokkaidensis* f. *fauriei* and var. *japonica*. Yamazaki (1993) recognized four varieties within *P. chamissonis*; var. *chamissonis*, var. *japonica*, var. *rebunensis*, and var. *longirostrata*. In this study, we concluded that *P. chamissonis* s.l. includes two species, *P. chamissonis* and *P. japonica*. Thus it is necessary to perform the examination of the intraspecific taxonomical treatment of both species. However, we do not have sufficient data for the examination. Therefore, in the present paper, we left the point for future study.

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ish Museum of Natural History (H), for sending digital images of type specimens. We also thank the directors and curators of KANA, KYO, MAK, SAPS, SHIN, TI, TNS for permission to examine specimens. This study was partly supported by a Grant-in-Aid for Young Scientists (A), Grant No. 15687003.

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